Pacific Northwest Rail Corridor

Everett to Blaine Commuter Rail Preliminary Feasibility Study

Technical Memorandum #3 – Rider Estimation

Prepared for the
Washington State Department of Transportation and Snohomish County

by
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July 2001

Washington State Department of Transportation

Snohomish County WASHINGTON

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The purpose of this technical memorandum is to describe the methodology and analytic process that was used to estimate ridership associated with a concept commuter rail service between Everett and Blaine on the Burlington Northern and Santa Fe Railway (BNSF) mainline. The objective of the overall study is to complete a preliminary feasibility analysis of ridership, station sites, and system constraints.

Other technical memoranda being produced for the Everett to Blaine Commuter Rail Preliminary Feasibility Study include:

- Technical Memorandum No. 1 – Station Site Evaluation
- Technical Memorandum No. 2 – Trackway Facility Constraints

Introduction

The purpose of this technical memorandum is to describe the process that was used to estimate the potential ridership market for a concept commuter rail service between Everett and Blaine. The concept commuter rail service would operate during weekday peak periods and make station stops in Everett, Marysville, English, Stanwood, Mt. Vernon, Bellingham, and Blaine. Ridership estimates were to be generated for two scenarios — 30 minute and 60 minute service — for the years 1998, 2010, 2020, and 2030.

The method used to prepare the ridership estimation is based on the analyses described in methodologies produced by the National Highway Cooperative Research Program (NCHRP), which follows a simplified four-step process. The first two steps, typically trip generation and trip distribution, were completed using the methods described in *NCHRP Report 365*: *Travel Estimation Techniques for Urban Planning*[1]. The Report is an update to *NCHRP Report 187*: *Quick-Response Urban Travel Estimation Techniques and Transferable Parameters*[2], and "provides a thorough review of the four step travel demand process and transferable parameters that can be used in simple planning analyses[3]." It is intended primarily for use by planners in smaller urban areas that do not have

[1] National Cooperative Highway Research Program (NCHRP) Report 365: Travel Estimation Techniques for Urban Planning, Transportation Research Board, Washington, D.C., 1998.
[2] National Cooperative Highway Research Program (NCHRP) Report 187: Quick-Response Urban Travel Estimation Techniques and Transferable Parameters, Transportation Research Board, Washington, D.C., 1978.
[3] NCHRP Report 365, foreword.

access to sophisticated modeling tools, or do not have the budget to support development of locally derived travel estimation parameters. As such, it is an excellent sketch-level planning tool.

The major steps of travel demand estimation as outlined in NCHRP Report 365 are ‘Building the Network and Socio-Economic Database,’ ‘Trip Generation,’ ‘Trip Distribution,’ ‘Mode Choice,’ and ‘Highway Assignment,’ the final four of which are those referred to by the ‘four-step’ title. For the purposes of this analysis, only the guidelines for Building the Database, Trip Generation, and Trip Distribution, as described in NCHRP Report 365, were used. These three steps allowed for an estimate of the travel demand in the study region. The methods detailed in the two final steps of NCHRP Report 365, namely Mode Choice and Highway Assignment, were not appropriate for use in this study for reasons that are explained in the section of the report under those titles. An alternative sketch level approach was developed to determine the maximum potential mode share and ridership that could be garnered by the proposed commuter rail service.

Data Collection

The process of data collection was aided significantly by the fact that much of the necessary data for this modeling effort had already been compiled by various agencies. The main sources of transportation analysis zone (TAZ) and network data were provided by the Skagit County Council of Governments (SCOG) Transportation Program, the U.S. Census, the Washington State Department of Transportation (WSDOT), the Puget Sound Regional Council (PSRC), TransLink, and the Vancouver B.C. Transportation Authority.

TAZ Data

The SCOG Transportation Program had compiled a rather comprehensive data set split out into 507 transportation analysis zones covering Snohomish, Skagit, Whatcom, and Island Counties. The boundaries for these analysis zones, in combination with the boundaries of the census tracts and the location of the rail and highway network, informed the size and shape of the TAZs defined for the Everett to Blaine Commuter Rail Preliminary Feasibility Study. The study area was divided into 30 TAZs covering the western parts of Snohomish, Skagit, and Whatcom Counties and the northern and eastern portions of Island County. Three external TAZs form the boundaries of the study area to the north and the south, representing Seattle, Bellevue, and the Vancouver, BC Census Metropolitan Area (CMA).

The SCOG data set included total population, total employment, and spotty coverage of retail employment, service employment, and other employment for the years 1998 and 2010. The employment data were established by place of employment. This data was augmented with U.S. Census data from 1990 for every tract in the region covering total population, total employment, employment by sector, total households, auto ownership by household, and various other measurements all collected by place of residence. Data for the external zones are provided from the research paper “Prospects for Sustainable Transportation in the Pacific Northwest: A comparison of Vancouver, Seattle, and Portland” by Preston Schiller and Jeffrey Kenworthy, the PSRC, and TransLink. The PSRC data consisted of total population, employment by sector, total households, auto ownership by household, and other measures for the years 1998, 2010, and 2020. Auto ownership rates were also gleaned from the Schiller-Kenworthy paper. The TransLink data consisted of total population, total households, and employment by sector for the years 1991 and 1998.

For the purposes of this modeling effort, it was necessary to use data for each North Sound area TAZ describing total population, total employment, employment by sector, total households, and auto ownership by household for the years 1998, 2010, 2020, and 2030. Much of this necessary data was covered by the collected data, but some gaps remained. As such, it was necessary to calculate a projection based on the existing data where any gaps in the data set existed. Total population, total households, and total employment were projected forward using the average yearly rate of change from previous years. Employment by sector was projected by determining the percentage split between the three categories (retail, service, and other employment), and applying that percentage split to the total employment for the desired year. Auto ownership by household was projected by calculating the percentage split between the four categories (zero, one, two, and three or more autos), and applying that percentage split to the total number of households for the desired year.

Projected data were compared with county level estimates furnished by the Washington Office of Financial Management (OFM). Where the projected values differed significantly from the OFM totals, the OFM data were used to constrain the projected total county values. After this step, the constrained county total was split back down to the TAZ level. This ensured that initial projected values did not depart significantly from reasonable totals. These socio-economic data are displayed in Tables 1 through 4.

Network Data

All of the highway network data used for this modeling effort were derived using the Washington State Department of Transportation (WSDOT) Travel Delay Methodology (TDM)[4] data. WSDOT provided a TDM spreadsheet that included the presently adopted State Highway System Plan Constrained 20-Year Mobility Strategies, coded into the ‘no build’ worksheet. The spreadsheet also included the State Highway System Plan Unconstrained Mobility Strategies in the ‘build’ worksheet. Both of these sets of strategies were considered in the modeling effort.

The TDM highway links that corresponded to the road segments represented in the model were aggregated into links with longer lengths. There were a total of 225 TDM links that were collapsed into 55 links for the model. The peak period travel speeds on the TDM links, in 1998 and 2022, were assigned to their corresponding Everett to Blaine Commuter Rail Preliminary Feasibility Study model link by taking their weighted average, as shown in Table 5. These speeds were projected to the years 2010, 2020, and 2030. From these speed estimates, the travel time on each North Sound corridor link for each horizon year was calculated. The result was a ‘build’ and ‘no build’ travel time for each link at each horizon year.

[4] Travel Delay Methodology (TDM) data provided by the WSDOT Transportation Planning Office (TPO), May 2001.

Trip Generation

The first step of the four-step process in travel demand modeling, trip generation, is described in detail in NCHRP Report 365. Trip generation is characterized by determining the origin end of trips (trip productions); determining the destination end of trips (trip attractions); and ensuring that the number of productions and attractions match (balancing productions and attractions). Once calculated, all trips are divided into three categories: home-based-work (HBW), home-based-other (HBO), and non-home-based (NHB). Rates of trip production and attraction are provided in NCHRP Report 365 for various urban area sizes. In this study, the rates for the smallest urban area size (50,000 to 199,999 inhabitants) are used due to the fact that the study area is a mix of urban and rural areas and that no cities in the study area exceed 199,999 persons in population.

Trip Productions

In order to calculate trip productions it is necessary to have population data that describes travelers' economic status (i.e., travel behavior varies by economic class). For this analysis, household economic status measure is measured by auto ownership. The total number of households is split into four categories, which equate to an average number of total daily trips as provided in NCHRP Report 365[5]:

- Zero Autos: 3.9 Trips per household
- One Auto: 6.3 Trips per household
- Two Autos: 10.6 Trips per household
- Three or more Autos: 13.2 Trips per household

These data are multiplied by the total number of households in each category in order to determine the total number of trips produced per day in each auto ownership category. The total number of trips produced by the households in the zone is then split out by trip purpose using rates provided in NCHRP Report 365[6]:

- HBW: 20 percent of total trips produced
- HBO: 57 percent of total trips produced
- NHB: 23 percent of total trips produced

[5] NCHRP Report 365, page 26
[6] NCHRP Report 365, page 29

Trip Attractions

In order to calculate trip attractions for each analysis area, it is necessary to have the total number of households (HH) and the total retail (RE), service (SE), and other (OE) employment. The employment data were collected at the actual location of employment, rather than the location of residence of the employees. As such, they are well suited for use in calculating zonal attractions. The following equations, as described in NCHRP Report 365[7], were used to calculate zonal attractions:

- HBW Attractions = 1.45 x Total Employment
- HBO Attractions = 9.00 x RE + 1.7 x SE + 0.5 x OE + 0.9 x HH
- NHB Attractions = 4.10 x RE + 1.2 x SE + 0.5 x OE + 0.5 x HH

These equations were developed for the purpose of calculating attractions in non-Commercial Business District (CBD) TAZs. It is more appropriate to use these equations than those developed for CBD zones because none of the zones developed for the study contain only CBD. In fact, all of the zones are made up mostly of non-CBD land. Therefore, it was most appropriate to perform the calculations with the non-CBD equations.

Balancing Productions and Attractions

It is necessary to balance the results of the production and attraction calculation process above, in order to ensure that every trip can have a beginning and an end. The result of the process is to have the same number of productions as attractions for each trip purpose. The balancing process was accomplished using the guidelines provided in NCHRP Report 365 [8]. It begins by adjusting the attractions values to the production values. The production values are typically assumed to be more accurate due to the fact that they are based on US Census data from home interviews. Attraction data are less reliable because they are workplace based and reporting technique can vary between employers.

Where
CT_p = the control total of productions
P_z = trip productions for each zone
P_e = trip productions at each external zone
A_e = trip attractions at each external zone

$CT_p = ?\,P_z + ?\,P_e - ?\,A_e$

Source: NCHRP Report 365, page 32.

[7] NCHRP Report 365, page 28
[8] NCHRP Report 365, page 32

Control totals, or the summary control values for the entire study area, were calculated for each trip purpose. Then balancing factors were calculated using the following equation:

Factor = CT_p / ? A_z

Where

A_z = trip attractions at each zone (by purpose)

Source: NCHRP Report 365, page 32.

At this point each zone's trip attractions are multiplied by the balancing factor. The result is the balanced value for trip attractions for each zone. Next, the NHB productions values are replaced with the NHB balanced attractions values. The reason for this replacement is that NHB trips have no trip end at home; using the data from the productions calculation process would be inaccurate since all of the data used therein are home-based. NHB trips are more accurately approximated by the data used in the trip attractions calculation process.

Trip Distribution

The second step in the four-step travel demand modeling process, trip distribution, allows the trips that were generated in the first step to be assigned to zone pairs. Necessary for this step, in addition to the data from trip generation, are travel times between each zone pair and intra-zonal travel times. These travel times are used to calculate friction factors, which are a representation of the spatial separation of each zone pair. Then the gravity model, using the calculated friction factors, distributes the trips between zone pairs.

Travel Time Estimation

In order to define the most accurate estimation of the spatial separation of each zone pair, the quickest travel path must be found. The quickest path may be either on highways or on railways. It is then necessary to use the quickest path by any mode between each zone pair for the calculation of friction factors. Thus, the quickest travel time between each zone pair must be calculated for each mode, and then the faster mode path used in the calculation of friction factors.

Highway Travel Times

Highway travel times between zones are calculated by using the link-specific impedance values for travel speed developed from the WSDOT TDM data. These travel speed data, as described before, were calculated for years 1998 and 2022, and were projected to years 2010, 2020, and 2030. Using these projected values for travel speed on the highway links, the shortest highway path between each zone pair was calculated. Because TAZs are large in this study, it is assumed that trips do not begin at the origin centroid, but that an average of 7.5 minutes of travel is required to go from the origin location to the origin centroid. Similarly, it is assumed that the same amount of time is required to travel by car to the destination location from the destination centroid. By adding the sum of the travel times onto consecutive highway links connecting each zone pair, the travel time to get from the origin onto the network, and travel time from the network to the destination, the inter-zonal travel times were calculated. As the result, travel times between each zone pair, both for free flow and congested travel were calculated for each horizon year.

Rail Travel Times

The shortest path between each zone pair via commuter rail was determined. Then all component links in the commuter rail travel time equation were added. The inter-zonal commuter rail travel time for each zone pair, as calculated by this model, depends on a series of components: 1) personal vehicle travel time from the origin location to the origin zone centroid, 2) personal vehicle travel on the highway network from the origin zone centroid to the commuter rail station, 3) wait time at the commuter rail station, 4) travel time on commuter rail links, 5) connection time to another public transit mode, 6) travel time on other public transit links to the destination zone centroid, and 7) travel time from the destination zone centroid to the destination location.

$T_r = C_o + C_r + W_r + R + X(n) + P_r + P_d$

Where

T_r = travel time (TT) for a trip with a commuter rail component

C_o = TT by car from origin location to origin zone centroid

C_r = TT by car from origin zone centroid to rail station

W_r = wait time at commuter rail station

R = TT on commuter rail

X = wait time for connections to public transit

n = number of connections between transit modes necessary

P_r = TT on other transit from rail to destination zone centroid

P_d = TT by transit or walking from destination centroid to final location

Not every trip that has a commuter rail component includes every one of these variables. Therefore, the unnecessary variables for any given zone pair are set to zero during the calculation process. The variable "C_r" is determined by the travel time along the shortest path from the origin zone centroid to the originating commuter rail station. The variable "R" is determined by the proposed commuter rail operating plan, which details travel times along the rail links between the origination and destination commuter rail stations (these travel times are based on average *Sounder*[9] run times). The minimum number of public transit connections necessary to reach the destination determines the variable "n." The variable "P_r" is determined by the estimated public transit travel time between the destination rail station and the destination zone centroid. The value of this variable is drawn from a variety of sources, depending on the shortest path. When the shortest path requires continued commuter rail travel to the south of Everett, the travel time is drawn from projected run times between stations. When the shortest path is over high-occupancy vehicle (HOV) lanes by bus, the travel time is assumed to be the sum of the highway link travel times when moving at the posted speed. When the shortest path is over non-HOV lanes by bus, the travel time is calculated from an assumed bus speed of 80 percent of the congested speeds on the highway links. This method is based on typical transit modeling practice. The variable "C_o" is assigned the value 7.5 minutes, just as in the calculation of highway travel times, as described above.

[9] Sound Transit Website: "http://www.soundtransit.org/sounder/timetables/6-11Timetables.htm"

Due to the fact that time and resources were significant limiting factors in relation to the scope of this analysis, many of the variables above are assumed to be equal for all trips that use them, including "W_r," "X," and "P_d." These variables were important for the calibration of the model; the values assigned to them are discussed later. After all the appropriate travel time variables have been added for each zone pair, the result is the estimated inter-zonal travel time by commuter rail for all zone pairs. After this was completed, the rail and highway assignment process was possible.

Intra-zonal Travel Times

Intra-zonal travel times were estimated using the 'Nearest Neighbor' technique, which "assumes that the travel time within a zone is equal to one-half the average travel time to the nearest adjacent zones"[10]. Intra-zonal travel times were calculated using free-flow travel speeds.

Friction Factors

The travel times calculated above are used to calculate the friction factors for travel between all zone pairs, including intra-zonal travel. Friction factors represent an approximation of the spatial separation of two zones, based on the travel time between them. The following equation, as described in NCHRP Report 365[11] (p 38), was used to calculated friction factors:

$$F_{ij} = a \times t_{ij}^{b} \times e^{c \times tij}$$

Where

F_{ij} = the friction factor between zones i and j

a, b, and c = gamma function coefficients

t_{ij} = the travel time between zones i and j

e = the base of the natural logarithm

[10] NCHRP Report 365, page 39

[11] NCHRP Report 365, page 38

The values used for gamma function coefficients a, b, and c are shown below. They were originally displayed in NCHRP Report 365[12], and were calculated from a series of other calibrated models for small urban areas in other parts of the country.

	a	b	c
HBW	28,507	-0.020	-0.123
HBO	139,173	-1.285	-0.094
NHB	219,113	-1.332	-0.100

Gravity Model

Once the friction factors have been calculated for each zone pair, horizon year, and scenario, they can be applied to the gravity model calculations to determine the overall trip distribution. The gravity model is based on the Newtonian law of the same name. The theory is that just as the "attraction between bodies is directly proportional to the mass of the bodies and inversely proportional to the square of the distance between the bodies,"[13] so the number of trips between two TAZs "is directly proportional to the number of … productions and attractions in each TAZ and inversely proportional to a function of the spatial separation" of the two zones.[14] For the gravity model calculations, all intra-zonal friction factors use free flow highway travel time while all inter-zonal friction factors use congested highway travel time. The gravity model formula is shown below:

$$T_{ij} = P_i \; (A_j F_{ij} / ? \; A_k F_{ik})$$

Where

T_{ij} = the number of trips from zone i to zone j

P_i = the number of trip productions in zone i

A_j = the number of trip attractions in zone j

F_{ij} = the friction factor relating spatial separation between zones i and j

k = the zone number

? = the sum from k=1 to k=highest zone number

When the gravity model calculations are complete, all the trips have been assigned an origin zone and a destination zone, and the total number of trips between each zone pair is known for each scenario and horizon year.

[12] NCHRP Report 365, page 41
[13] NCHRP Report 365, page 37
[14] NCHRP Report 365, page 37

Mode Choice

The mode choice component of the model is based strictly on travel time between zones. This means simply that all trips between two zones are assigned to whichever mode is faster for a given horizon year and scenario. This component was developed apart from the guidelines of NCHRP Report 365. The methods described in NCHRP Report 365 for estimating mode choice were not used due to the fact that they are not appropriate for determining the suitability of new transit lines. Transit assignment in the Everett to Blaine commuter rail corridor model is accomplished by finding the sum of all trips between the inter-zonal pairs for which commuter rail offers the best travel time.

Highway Assignment

The highway assignment component of NCHRP Report 365 was not used in this study because an adequate highway assignment study had been accomplished by WSDOT using the TDM and because the purpose of the study was not to determine highway assignment. Due to the sketch level of this analysis, the TAZs and highway network were not created at a detailed enough level for the highway assignment procedures detailed in NCHRP Report 365 to be meaningful. The highway assignment process for this model was completed initially, through the use of the WSDOT TDM, for the purpose of calculating friction factors. The TDM Program produced annual average daily traffic values, along with travel speeds on all highway links, as described previously. This initial highway assignment covered all travel on the roads in the corridor, not just travel within the study area. Additionally, the initial highway assignment process did not deal with highway travel by zone pair. However, as stated earlier, the focus of this analysis was not on the ending highway assignment, but on the ending rail assignment. Highway assignment data were important only in order to project highway travel times for comparison with commuter rail travel times. In other words, while highway assignment is typically the final step in the four-step travel demand modeling process, for the purposes of this analysis, only sketch level highway assignment data were necessary in order to calculate friction factors.

Rail Assignment

The rail assignment process was completed, through comparison of zone pair travel times by highway with zone pair travel times by commuter rail, for both ‘build’ and ‘no build’ scenarios at each horizon year. It is assumed that a potential commuter rail passenger may travel either north or south on rail from their boarding station at the specified service frequency (either half-hourly or hourly during peak periods only). In each case where the better travel time is achieved by rail, it is assumed that all of the trips for that zone pair are taken by commuter rail; this is an all-or-nothing assignment process. Trips for each zone-to-zone travel pair are assumed to board and deboard the commuter rail service at a single location. Therefore, the total of trips assigned to commuter rail can be split out by boarding location.

This analysis was performed in the detail described only for HBW trips, due to the fact that the primary market for the proposed commuter rail would be those commuters traveling to and from work. HBO and NHB trips tend to have significantly shorter trip lengths than HBW, making commuter rail less of an attractive option. Additionally, the rail operating plans that are analyzed in this study include primarily peak-period-oriented service, which caters more to HBW trips than to trips of other purposes. The result of the rail assignment process is an estimate of the number of trips that would be quicker by commuter rail at each horizon year for both ‘build’ and ‘no build’ scenarios.

Calibrations and Assumptions

The basic tenets of the modeling process are described above. Once this process was completed it was necessary to run the model a number of times to determine the most accurate values for the variables below and the most defensible methods for the calculations listed.

Wait time for Rail (W_r)

This variable in the travel time calculation process represents two components of the commuter rail travel time. First, it approximates the wait time for rail, or all of the time between when the passenger arrives at the station and when the train pulls away from the station with the passenger inside. The second component of the wait time variable is a time penalty for non-continuous service, or a representation of the difference in convenience between leaving for work whenever one desires and leaving for work at a specific time in order to get on a train. The two different operating plan frequency scenarios, half hourly service and hourly service, have different time penalties. The entire difference in projected ridership between the half-hourly and the hourly service scenarios is based on this difference in the convenience penalty component of the wait time variable.

The first component of the wait time variable, which is the actual measurement of time between arriving by car and leaving the station on the train, is assumed to be 15 minutes for both half-hourly and hourly service scenarios. The second component of the wait time variable, or the convenience penalty, is assumed to be 7.5 minutes for the half-hourly scenario and 18.75 minutes for the hourly scenario.

In the case of the half hour penalty, the maximum possible difference between when an individual would leave for work by car and when they would leave for work by train is 15 minutes, due to the fact that the service is half hourly. It is assumed that commuters leave to get to work in an even distribution over the course of the peak period. As such, the average difference between when a commuter would leave to go to work by car and when they would leave to go to work by train is 7.5 minutes. This is the half-hourly penalty.

In the case of the hourly penalty, the maximum possible difference between when an individual would leave to go to work by car and when they would leave to go to work by train is 30 minutes, due to the fact that the service is hourly. However, most commuters cannot delay as much as 30 minutes and still get to work on time. As such, commuters are assumed to be capable of delaying no more than 15 minutes to take a train that leaves later than they normally would. If their delay is more than 15 minutes, it is assumed that they must instead take the earlier train, which is as much as 45 minutes earlier. The average difference then, assuming that commuters leave to get to work in an even distribution over the course of the peak period, between when a commuter would leave for work by car and when they would leave for work by rail, is 18.75 minutes.

The total value of the wait time variable, the sum of the station wait time component and the convenience penalty component, for the half-hourly frequency scenario, is assumed to be 22.5 minutes. The total value of the wait time variable for the hourly frequency scenario, using the same calculations, is assumed to be 33.75 minutes.

Transit and/or Walk Time From Destination Zone Centroid to Final Destination Location for Commuter Rail Trips (P_d)

When the inter-zonal highway travel times were calculated, the time assigned to the travel between the destination zone centroid and the final destination location was 7.5 minutes, as described earlier. In this instance, the traveler is driving a car on local roads and walking a short distance to their place of employment. In the case of commuter rail trips, the travel time for the distance between the destination zone centroid and the destination location is assumed to be 15 minutes. The reason for the increased travel time is that the commuter rail traveler is either traveling on public transit and then on foot, or traveling only on foot. In either instance, the traveler has to walk from a transit stop to their place of work for at least part of this leg. This is almost always more time costly than using a car. As such, the travel time for this leg for a commuter rail traveler is twice as great as for a traveler moving by auto.

Connection Time (X)

The average connection time between any two public transit modes is assumed to be 15 minutes. Embedded in this value is the assumption that in the future, timely connections will be possible from the commuter rail stations through timed-transfer public transit, and that little delay will result from switching transit modes.

Number of Connections (n)

For the purposes of this modeling effort, connections are assumed to exist if a trip between two zones requires additional travel on the model network after reaching the final commuter rail station for that trip. For example, a trip from Stanwood to Everett is assumed to have no connections because no additional travel on the model network is required to reach the Everett centroid from the Everett commuter rail station. A trip from Stanwood to Snohomish is assumed to have one connection because it is necessary to connect from the Everett to Blaine commuter rail line to a bus route in Everett.

Friction Factors

The friction factors calculated in the trip distribution process, as described earlier, were based on the quickest path by any mode between zone pairs at each horizon year. Other options that were not employed included using the best congested highway travel time between zone pairs, using free flow travel times between zone pairs, or using a single year's congested travel times. The first method for calculating friction factors was determined to be the most appropriate for a number of reasons.

The friction factors were developed specifically for use with HBW trips, the only type of trip analyzed in detail in this study. HBW trips occur most frequently during the peak-periods of travel during the day, as such, the commuter's trip making behavior is determined by congested travel times. Thus, the best congested travel times by any mode for each horizon year, rather than free flow, posted speed, or congested times from a single year, provide a better measure of the spatial separation of each zone pair during the typical time for HBW travel: the peak-period. Additionally, it is more reasonable to use the best travel time by any mode, rather than by a single mode, when calculating friction factors because commuters are sensitive to the quickest travel path; unless the quickest path can be chosen from among all modes, there is a chance that the quickest path will not be represented.

Using the free flow highway travel time to calculate friction factors is a common practice if the modeling effort is concentrated on all trip purposes, or only on HBO and NHB trip purposes. This can be a valid approach because most trips are either HBO or NHB, and most of these trips occur on local roads and non-peak hours, so congestion is minimal. However, this approach is not appropriate for this analysis because only HBW trips are being analyzed.

Using the best congested travel time by highway as the basis for the spatial separation between zones is not appropriate for this modeling effort. Despite the fact that most HBW trips occur on highways, some trips are not, especially when a quicker option is available by another mode. If friction factors were based off of this measurement of travel time, the result would be that the more distant zones would have an artificially high metric of spatial separation, and too few trips would be distributed to the more distant zone pairs. When it is quicker to travel by rail than by highway between two zones, the friction factor describing the spatial separation of those two zones should reflect that fact.

Using a single year's congested travel time as the basis for the spatial separation of the zones is also inappropriate for this analysis. By using such a travel time, the modeler would be assuming that changes in travel time over the years would not affect commuters' perception of spatial separation of locations. This would be an incorrect assumption. It is necessary that changes in travel time between zones over the years be reflected in the commuters' concept of the spatial separation of zones, and that said changes affect their willingness to commute those distances. For this reason, it is necessary to employ the congested highway travel time between zone pairs for each horizon year as the basis for the generation of zone to zone friction factors.

Caveats of the Methodology Used in the Everett to Blaine Commuter Rail Preliminary Feasibility Study

The methods described in NCHRP Report 365 were developed specifically for use in a metropolitan region, while in this study they have been applied to a mixed urban and rural area. However, the travel behavior and average trip lengths characteristic of the North Sound region are very similar to those in most small urban areas. As such, the application of the methods outlined in NCHRP Report 365 is appropriate.

Further research should be conducted on other approaches to statewide modeling regarding the use of friction factors. In NCHRP Report 365 it is recommended that standard regional friction factors be applied for use in smaller urban areas. However, some travel within the North Sound study area could potentially be construed as inter-regional rather than regional, due to the large size of the study area. As such, it would be useful to study the applicability of regional friction factors in the Everett to Blaine commuter rail ridership estimation analysis.

Mode choice is a key and complicated component of determining the potential ridership for a proposed commuter rail line. It is stated in NCHRP Report 365, that the mode choice analysis methods discussed therein are not suitable for the purpose of this analysis. As such, the NCHRP mode choice methods have not been used. However, a mode choice method based simply on travel time, as used in this study, is a gross oversimplification of the actual factors affecting mode choice. The values produced as a result of this study should be viewed as the number of trips that may be quicker if taken by commuter rail, or a highest end estimate of ridership. In many cases, commuters will choose to drive to work in their own car, even when transit may be faster, for reasons of convenience or preference.

Unfortunately, the time restraints related to this study did not allow for significant development of a more sophisticated mode choice method. Additional research into mode split in other parts of the country may be helpful for further refinement of the mode choice methods employed in this analysis.

Results

A number of basic preliminary conclusions can be drawn from the result data assembled in this sketch level analysis of ridership. However, before these conclusions are advanced further, they should be confirmed using a more detailed and in-depth modeling approach. The following results are for the projected home-based-work trips only.

In this modeling effort, two sets of highway network data were analyzed — the presently adopted State Highway System Plan Constrained 20-Year Mobility Strategies, known as the 'no build' scenario, and the State Highway System Plan Unconstrained Mobility Strategies, known as the 'build' scenario. The total projected daily boardings for each scenario are shown in Table 6. The difference between 'build' and 'no build' scenarios, in terms of ridership garnered by the proposed commuter rail service, is statistically insignificant. Thus, for simplicity's sake only the results from the 'no-build' scenario are discussed here.
It's also clear from Table 6 that the difference in ridership estimated for the half-hourly service and the hourly service is significant. According to the results of this modeling effort, the proposed half-hourly commuter rail service could generate as many as 1,415 one-way trips by the year 2020. By the year 2030, the demand for the half-hourly service could be as great as 8,299 one-way trips daily.

Table 6
Differences in Projected Ridership by Highway Build Scenario

Service Scenario	Half Hour				Hour			
Year	**1998**	**2010**	**2020**	**2030**	**1998**	**2010**	**2020**	**2030**
Total One-Way Trips: 'no build'	0	10	1,415	8,299	0	0	144	2,130
Total One-Way Trips: 'build'	0	8	1,350	8,237	0	0	137	2,106

According to the model, the hourly service scenario, by the year 2020, will probably not see the same level of demand as the half-hourly service. The projected number of one-way trips on the hourly service commuter rail could be as high as 144, however, by the year 2030, the hourly service could generate as many as 2,130 one-way trips daily.

The ridership estimation modeling process yielded data regarding the location of boardings. While this modeling effort was not detailed enough to lend reliability to the data derived specifically by station, there are some conclusions that can be drawn based on the estimates of boarding location produced by the ridership estimation model. As shown in Table 7, the preponderance of passengers in the modeled scenarios board at the Snohomish County stations. At every horizon year the percentage of the total boardings that are made in Snohomish County is 90 percent of total service ridership or greater. In most instances the percentage is closer to 98 percent or 99 percent. Few if any riders are projected to board at Blaine, Bellingham or Mt. Vernon. The reason the model produces these results is that the travel times on I-5 in Snohomish County are projected to deteriorate much sooner than the travel times on I-5 in Whatcom and Skagit counties. As a result, highway travel is projected to remain an agreeable option for commuters in Whatcom and Skagit counties, even in the years 2020 and 2030.

Table 7
Projected Daily One-Way Trips by Station
(no-build)

Service	**Half Hour**				**Hour**			
Year	**1998**	**2010**	**2020**	**2030**	**1998**	**2010**	**2020**	**2030**
Blaine	0	0	0	12	0	0	0	3
Bellingham	0	1	8	15	0	0	2	4
Mt. Vernon	0	0	12	24	0	0	2	6
Stanwood	0	1	375	480	0	0	24	122
English	0	1	446	1,200	0	0	41	306
Marysville	0	3	201	3,490	0	0	16	899
Everett	0	4	372	3,078	0	0	60	792
Total	0	10	1,415	8,299	0	0	144	2,130

The final set of resultant data from the ridership estimation modeling process describe the percentage of HBW trips in the study area that are made on the commuter rail service, or mode share. These data are shown in Table 8. For every year and service scenario the percentage of HBW trips made in the study area that are made by commuter rail is relatively minor (i.e., less than one tenth of one percent of total corridor trips). This figure includes all HBW trips in the study area, even those classified as intra-zonal, or of very short distance. However, when only the inter-zonal trips, or the trips of longer distance, are considered, the percentage of HBW trips made by commuter rail is significantly higher, as high as 4.28 percent. These figures reveal that although the total estimated ridership on the proposed commuter rail line might appear high for an area with a rather rural landscape, the actual level of use, in comparison to the overall trip making behavior, is rather low. Even when only commuters traveling relatively long distances to work are considered, the maximum mode share of the commuter rail line is very small.

Table 8
Percentage of Study Area HBW Trips
Made on Commuter Rail

Frequency of Service	Half Hour				Hour			
Year	**1998**	**2010**	**2020**	**2030**	**1998**	**2010**	**2020**	**2030**
% of all HBW trips in study area made on commuter rail	0.00%	0.00%	0.02%	0.08%	0.00%	0.00%	0.00%	0.02%
$ of inter-zonal HBW trips in study area made on commuter rail	0.00%	0.00%	0.62%	4.28%	0.00%	0.00%	0.06%	1.13%

Conclusions

The results of this preliminary ridership estimation study suggest that the level of demand, due largely to high levels of ridership from north Snohomish County, may support half-hourly commuter rail service by the year 2030. However, more detailed research would be necessary to confirm these findings before implementing a commuter rail service.

Table 1
1998 Socio-Economic TAZ Data

TAZ	County	Total Population	Total Households	0 Auto Households	1 Auto Households	2 Auto Households	3+ Auto Households	Total Employment	Retail Employment	Service Employment	Other Employment
Blaine	Whatcom	15,992	6,198	202	1,569	2,579	1,848	4,035	1,050	1,473	1,512
Lynden	Whatcom	24,472	8,260	281	1,895	3,529	2,555	8,135	2,117	2,969	3,049
Ferndale	Whatcom	15,324	5,439	259	1,223	2,287	1,671	6,565	1,708	2,396	2,461
Lummi	Whatcom	6,103	2,166	55	643	980	493	1,174	305	428	440
West Bellingham	Whatcom	15,551	6,421	342	2,163	2,515	1,359	8,442	2,197	3,081	3,164
East Bellingham	Whatcom	34,471	13,799	1,239	4,340	5,374	2,748	29,367	7,641	10,719	11,007
South Bellingham	Whatcom	28,351	11,202	829	4,063	4,254	2,037	8,294	2,158	3,027	3,109
Lake Whatcom	Whatcom	8,085	3,185	109	978	1,518	731	322	84	118	121
Edison	Skagit	5,147	1,844	27	300	766	751	1,099	179	543	377
Sedro Woolley	Skagit	13,045	4,706	342	1,341	1,891	1,111	4,849	871	1,971	2,007
Burlington	Skagit	8,834	3,433	184	1,103	1,275	893	6,433	2,633	1,305	2,495
Fredonia	Skagit	10,216	4,015	83	878	1,924	1,130	4,775	739	889	3,147
Anacortes	Skagit	20,014	8,148	430	2,457	3,488	1,773	6,392	1,317	2,053	3,022
Mt. Vernon	Skagit	23,327	9,038	606	2,901	3,611	1,921	15,990	4,544	6,415	5,031
Mountborne	Skagit	3,752	1,405	41	348	537	480	370	33	109	228
Conway	Skagit	3,121	1,098	19	172	498	408	433	85	82	266
Oak Harbor	Island	40,313	13,006	605	4,036	5,602	2,763	8,400	1,882	2,759	3,759
Camano	Island	12,372	5,289	111	1,442	2,439	1,296	470	60	160	250
Stanwood	Snohomish	15,086	5,368	227	1,350	1,870	1,896	4,258	777	1,925	1,556
Pilchuck	Snohomish	4,834	1,604	25	177	653	749	253	0	76	159
Trafton	Snohomish	8,883	2,917	36	466	1,134	1,281	798	19	236	543
Arlington	Snohomish	29,810	10,060	363	2,176	4,373	3,224	13,858	2,266	3,138	8,167
Marysville	Snohomish	40,259	14,820	681	4,044	6,141	3,924	10,994	3,080	4,780	2,916
Lake Stevens	Snohomish	38,758	13,435	448	2,728	5,686	4,565	6,934	1,360	2,006	3,568
Everett	Snohomish	45,070	18,702	2,683	7,022	6,055	2,971	32,324	4,100	15,968	12,093
Snohomish	Snohomish	22,020	7,664	411	1,598	2,942	2,704	6,510	1,690	2,265	2,143
Monroe	Snohomish	31,620	10,700	445	2,300	4,586	3,369	9,543	2,461	2,466	4,616
Mukilteo	Snohomish	126,164	48,203	1,539	14,572	20,848	11,221	84,270	10,441	14,684	56,955
Clearview	Snohomish	43,091	13,881	135	1,663	6,892	5,263	8,816	630	2,466	5,571
Edmonds	Snohomish	158,910	59,966	2,259	16,960	25,879	14,811	58,825	14,621	24,902	17,130
Seattle	King	619,910	280,332	43,340	110,619	86,959	37,443	505,672	62,309	256,679	186,684
Bellevue	King	378,026	146,841	4,477	38,285	66,028	36,006	245,688	36,980	116,296	92,412
Vancouver, BC	B. C.	1,936,436	730,934	109,640	285,064	241,208	95,021	915,600	122,100	477,000	316,500

Source: HDR Engineering, projected from data provided by SCOG Transportation Program, US Census, PSRC, TransLink, and Shiller-Kenworthy Paper.

Table 2
2010 Socio-Economic TAZ Data

TAZ	County	Total Population	Total Households	0 Auto Households	1 Auto Households	2 Auto Households	3+ Auto Households	Total Employment	Retail Employment	Service Employment	Other Employment
Blaine	Whatcom	16,792	6,417	209	1,625	2,670	1,914	6,142	1,777	2,153	2,212
Lynden	Whatcom	29,403	13,255	451	3,041	5,663	4,100	10,082	2,537	3,722	3,823
Ferndale	Whatcom	19,926	8,985	428	2,021	3,777	2,761	7,651	1,124	3,220	3,307
Lummi	Whatcom	6,358	2,257	57	670	1,021	513	1,926	124	889	913
West Bellingham	Whatcom	14,769	6,657	354	2,242	2,607	1,409	6,749	552	3,057	3,140
East Bellingham	Whatcom	33,973	16,474	1,479	5,181	6,416	3,281	19,035	4,249	7,295	7,491
South Bellingham	Whatcom	31,772	14,771	1,093	5,358	5,610	2,686	19,416	5,435	6,898	7,083
Lake Whatcom	Whatcom	11,558	3,397	116	1,043	1,619	780	788	143	318	327
Edison	Skagit	5,122	1,835	27	299	763	747	1,317	337	846	134
Sedro Woolley	Skagit	19,534	7,047	512	2,009	2,831	1,664	4,914	809	2,120	1,985
Burlington	Skagit	12,064	4,688	251	1,506	1,741	1,219	9,728	4,787	1,854	3,087
Fredonia	Skagit	10,778	4,236	87	927	2,030	1,192	8,502	2,026	1,092	5,384
Anacortes	Skagit	20,273	8,254	436	2,489	3,533	1,796	10,052	1,921	2,483	5,649
Mt. Vernon	Skagit	34,781	13,475	903	4,326	5,384	2,864	20,640	5,852	7,624	7,164
Mountborne	Skagit	6,406	2,399	69	593	916	820	1,430	779	290	361
Conway	Skagit	5,232	1,841	32	289	834	684	275	98	134	43
Oak Harbor	Island	49,315	15,910	740	4,937	6,853	3,380	11,639	2,786	3,856	4,997
Camano	Island	17,076	7,300	154	1,990	3,367	1,789	908	262	267	379
Stanwood	Snohomish	19,420	7,484	316	1,882	2,607	2,643	4,410	931	2,395	1,084
Pilchuck	Snohomish	5,905	2,106	33	232	858	984	256	50	110	96
Trafton	Snohomish	9,132	3,204	40	512	1,245	1,407	510	38	256	216
Arlington	Snohomish	39,097	14,277	515	3,088	6,207	4,575	16,936	2,706	5,748	8,482
Marysville	Snohomish	58,954	23,144	1,063	6,315	9,591	6,129	11,390	3,445	5,896	2,049
Lake Stevens	Snohomish	51,050	18,998	634	3,857	8,040	6,455	8,218	2,171	3,818	2,229
Everett	Snohomish	52,251	22,173	3,181	8,325	7,178	3,522	47,709	6,063	21,052	20,594
Snohomish	Snohomish	24,936	9,288	498	1,937	3,565	3,277	5,933	1,734	2,790	1,409
Monroe	Snohomish	41,241	15,262	635	3,281	6,541	4,805	9,416	2,736	2,868	3,812
Mukilteo	Snohomish	169,793	69,670	2,224	21,062	30,133	16,218	95,124	12,255	22,041	60,828
Clearview	Snohomish	66,432	23,000	223	2,756	11,420	8,720	9,486	1,303	3,606	4,577
Edmonds	Snohomish	203,673	81,356	3,065	23,009	35,110	20,094	71,781	19,000	35,974	16,807
Seattle	King	699,821	345,208	53,370	136,219	107,084	46,109	640,923	85,076	375,732	180,115
Bellevue	King	436,718	184,651	5,630	48,144	83,030	45,277	301,526	56,194	165,206	80,126
Vancouver, BC	B. C.	2,601,021	971,265	145,690	378,793	320,518	126,264	1,163,597	155,172	606,199	402,226

Source: HDR Engineering, projected from data provided by SCOG Transportation Program, US Census, PSRC, TransLink, Shiller-Kenworthy Paper, and Washington State OFM.

Table 3
2020 Socio-Economic TAZ Data

TAZ	County	Total Population	Total Households	0 Auto Households	1 Auto Households	2 Auto Households	3+ Auto Households	Total Employment	Retail Employment	Service Employment	Other Employment
Blaine	Whatcom	17,492	6,685	217	1,693	2,781	1,994	8,815	2,550	3,091	3,174
Lynden	Whatcom	34,340	15,481	527	3,551	6,614	4,788	12,093	3,043	4,465	4,585
Ferndale	Whatcom	24,913	11,234	535	2,527	4,723	3,452	8,706	1,279	3,664	3,763
Lummi	Whatcom	6,579	2,335	59	693	1,057	531	2,954	190	1,364	1,400
West Bellingham	Whatcom	14,150	6,378	340	2,148	2,498	1,350	5,621	460	2,546	2,615
East Bellingham	Whatcom	33,564	16,276	1,461	5,119	6,339	3,241	13,454	3,003	5,156	5,295
South Bellingham	Whatcom	34,967	16,256	1,202	5,897	6,174	2,956	41,113	11,508	14,605	14,999
Lake Whatcom	Whatcom	15,695	4,613	158	1,417	2,198	1,059	1,738	315	702	721
Edison	Skagit	5,101	1,827	27	297	759	744	1,535	393	986	156
Sedro Woolley	Skagit	27,631	9,968	724	2,841	4,005	2,354	4,969	818	2,144	2,007
Burlington	Skagit	15,740	6,117	327	1,965	2,272	1,591	13,880	6,831	2,645	4,404
Fredonia	Skagit	11,272	4,430	91	969	2,123	1,247	14,032	3,344	1,802	8,887
Anacortes	Skagit	20,492	8,343	441	2,516	3,571	1,815	14,849	2,838	3,667	8,344
Mt. Vernon	Skagit	49,013	18,989	1,273	6,095	7,587	4,037	25,641	7,270	9,471	8,900
Mountborne	Skagit	10,182	3,813	110	943	1,456	1,303	4,844	2,639	982	1,222
Conway	Skagit	8,181	2,879	51	452	1,304	1,069	192	69	93	30
Oak Harbor	Island	58,492	18,871	878	5,856	8,128	4,009	15,379	3,681	5,095	6,603
Camano	Island	22,486	9,612	202	2,620	4,433	2,356	1,613	465	474	673
Stanwood	Snohomish	22,912	8,830	373	2,220	3,076	3,118	4,542	959	2,466	1,117
Pilchuck	Snohomish	6,659	2,375	37	261	967	1,109	258	50	111	97
Trafton	Snohomish	9,345	3,279	41	523	1,275	1,440	356	27	179	151
Arlington	Snohomish	46,880	17,119	618	3,702	7,442	5,486	20,071	3,207	6,812	10,052
Marysville	Snohomish	77,837	30,557	1,404	8,338	12,663	8,092	11,731	3,548	6,073	2,110
Lake Stevens	Snohomish	61,439	22,864	762	4,642	9,676	7,769	9,487	2,506	4,407	2,573
Everett	Snohomish	56,343	23,910	3,430	8,977	7,741	3,798	66,632	8,468	29,402	28,763
Snohomish	Snohomish	26,357	9,817	527	2,047	3,769	3,464	5,495	1,606	2,584	1,305
Monroe	Snohomish	49,213	18,212	758	3,915	7,805	5,734	9,312	2,706	2,836	3,770
Mukilteo	Snohomish	208,209	85,433	2,728	25,827	36,951	19,887	105,335	13,570	24,407	67,358
Clearview	Snohomish	91,784	31,777	308	3,807	15,778	12,048	10,086	1,385	3,834	4,866
Edmonds	Snohomish	239,394	95,625	3,602	27,045	41,268	23,619	84,955	22,487	42,576	19,891
Seattle	King	757,288	379,499	58,671	149,750	117,721	50,689	683,742	93,046	405,552	185,144
Bellevue	King	483,417	206,749	6,304	53,905	92,966	50,696	330,422	63,550	184,516	82,356
Vancouver, BC	B. C.	3,344,913	1,237,392	185,609	482,583	408,339	160,861	1,426,237	190,196	743,027	493,015

Source: HDR Engineering, projected from data provided by SCOG Transportation Program, US Census, PSRC, TransLink, Shiller-Kenworthy Paper, and Washington State OFM.

Table 4
2030 Socio-Economic TAZ Data

TAZ	County	Total Population	Total Households	0 Auto Households	1 Auto Households	2 Auto Households	3+ Auto Households	Total Employment	Retail Employment	Service Employment	Other Employment
Blaine	Whatcom	18,221	6,963	226	1,763	2,897	2,077	12,650	3,660	4,435	4,555
Lynden	Whatcom	40,106	18,080	616	4,148	7,724	5,593	14,505	3,650	5,355	5,500
Ferndale	Whatcom	31,147	14,045	668	3,159	5,905	4,316	9,906	1,455	4,169	4,281
Lummi	Whatcom	6,808	2,416	61	718	1,093	549	4,531	292	2,091	2,148
West Bellingham	Whatcom	13,557	6,111	325	2,058	2,393	1,293	4,682	383	2,121	2,178
East Bellingham	Whatcom	33,160	16,080	1,444	5,057	6,263	3,202	9,510	2,123	3,644	3,743
South Bellingham	Whatcom	38,483	17,891	1,323	6,490	6,795	3,254	87,055	24,369	30,926	31,760
Lake Whatcom	Whatcom	21,314	6,264	215	1,924	2,985	1,438	3,835	696	1,549	1,590
Edison	Skagit	5,081	1,820	27	296	756	741	1,788	458	1,148	182
Sedro Woolley	Skagit	39,085	14,100	1,024	4,019	5,665	3,330	5,025	828	2,168	2,030
Burlington	Skagit	20,536	7,980	427	2,564	2,964	2,075	19,804	9,746	3,774	6,284
Fredonia	Skagit	11,789	4,634	95	1,013	2,221	1,304	23,160	5,519	2,974	14,667
Anacortes	Skagit	20,713	8,433	445	2,543	3,609	1,835	21,936	4,192	5,417	12,326
Mt. Vernon	Skagit	69,068	26,759	1,793	8,590	10,691	5,688	31,855	9,032	11,766	11,057
Mountborne	Skagit	16,184	6,060	175	1,499	2,315	2,071	16,406	8,940	3,325	4,141
Conway	Skagit	12,792	4,501	79	706	2,039	1,672	133	48	65	21
Oak Harbor	Island	69,376	22,382	1,041	6,945	9,641	4,755	20,321	4,864	6,732	8,724
Camano	Island	29,611	12,658	267	3,450	5,838	3,103	2,866	827	843	1,196
Stanwood	Snohomish	27,032	10,418	440	2,619	3,629	3,679	4,677	987	2,540	1,150
Pilchuck	Snohomish	7,509	2,678	42	295	1,091	1,251	261	51	112	98
Trafton	Snohomish	9,564	3,355	42	536	1,304	1,474	249	19	125	105
Arlington	Snohomish	56,212	20,527	741	4,439	8,924	6,578	23,787	3,801	8,073	11,913
Marysville	Snohomish	102,768	40,345	1,854	11,009	16,719	10,684	12,083	3,655	6,255	2,173
Lake Stevens	Snohomish	73,943	27,518	918	5,587	11,646	9,350	10,951	2,893	5,087	2,970
Everett	Snohomish	60,756	25,782	3,699	9,680	8,347	4,096	93,061	11,826	41,064	40,171
Snohomish	Snohomish	27,859	10,377	557	2,164	3,983	3,662	5,089	1,487	2,393	1,208
Monroe	Snohomish	58,726	21,733	904	4,672	9,314	6,843	9,209	2,676	2,805	3,728
Mukilteo	Snohomish	255,317	104,763	3,345	31,671	45,311	24,387	116,641	15,027	27,027	74,588
Clearview	Snohomish	126,811	43,904	426	5,260	21,799	16,645	10,724	1,473	4,077	5,174
Edmonds	Snohomish	281,381	112,396	4,234	31,788	48,506	27,761	100,547	26,614	50,391	23,542
Seattle	King	819,474	410,662	63,489	162,047	127,388	54,851	729,422	99,262	432,647	197,513
Bellevue	King	535,110	228,857	6,978	59,669	102,907	56,117	362,087	69,640	202,199	90,248
Vancouver, BC	B. C.	4,301,558	1,576,438	236,466	614,811	520,224	204,937	1,748,159	233,126	910,738	604,295

Source: HDR Engineering, projected from data provided by SCOG Transportation Program, US Census, PSRC, TransLink, Shiller-Kenworthy Paper, and Washington State OFM.

Table 5
Travel Delay Methodology (TDM) Derived Network Link Travel Times and Speeds for TDM Horizon Years

Route	Link Description	Length (miles)	Posted Speed (mph)	Free Flow Travel Time (minutes)	1998 Congested Travel Speed (mph)	1998 Congested Travel Time (minutes)	2022 “No-Build” Congested Travel Speed (mph)	2022 “No-Build” Congested Travel Time (minutes)	2022 “Build” Congested Travel Speed (mph)	2022 “Build” Congested Travel Time (minutes)
2	Everett to 9xing	5.91	55	6.45	54	6.54	43	8.33	43	8.33
2	9xing to Snohomish	3.07	55	3.35	43	4.27	31	6.01	31	6.01
2	Snohomish to Monroe	5.73	55	6.25	23	14.65	13	25.84	13	25.84
5	Seattle to 520xing	3.49	60	3.49	37	5.62	15	13.55	15	13.55
5	520xing to 522xing	2.32	60	2.32	49	2.83	18	7.95	18	7.95
5	522xing to Edmonds	10.03	60	10.03	37	16.48	16	37.52	16	37.52
5	Edmonds to 405/525xing	1.08	60	1.08	45	1.43	16	4.07	16	4.07
5	405/525xing to 526xing	6.7	60	6.70	24	16.61	14	27.81	14	27.81
5	526xing to Everett	4.43	60	4.43	36	7.47	15	17.39	15	17.39
5	Everett to Marysville	5.4	60	5.40	45	7.15	16	20.33	16	20.33
5	Marysville to Smokey Point	6.92	65	6.39	65	6.34	21	19.77	21	19.77
5	Smokey Point to 530xing	2.59	70	2.22	74	2.10	25	6.32	25	6.32
5	530xing to 532xing	6.58	70	5.64	74	5.32	29	13.57	29	13.57
5	532xing to Conway	5.84	70	5.01	75	4.67	41	8.47	57	6.14
5	Conway to Mt Vernon	5.32	67	4.76	69	4.60	44	7.23	70	4.54
5	Mt Vernon to 538xing	1.36	60	1.36	46	1.78	16	5.12	16	5.12
5	538xing to 20xing	2.39	65	2.21	51	2.79	17	8.36	17	8.36
5	20xing to Bow Hill Rd. xing	6.25	70	5.36	75	5.02	41	9.11	41	9.11
5	Bow Hill Rd. xing to South Bellingham	14.38	67	12.88	70	12.39	25	34.50	63	13.65
5	S. Bellingham to L. Whatcom Blvd xing	2.22	60	2.22	58	2.28	19	7.05	57	2.35
5	Lake Whatcom Blvd xing to 542xing	1.83	60	1.83	49	2.23	16	6.89	45	2.44
5	542xing to 539xing	1.42	60	1.42	52	1.65	16	5.35	47	1.80
5	539xing to West Bellingham	1.42	60	1.42	61	1.39	25	3.46	60	1.42
5	West Bellingham to Ferndale	5.39	67	4.83	70	4.63	35	9.34	68	4.75
5	Ferndale to Blaine	13.18	70	11.30	77	10.33	67	11.73	76	10.41
9	522xing to Clearview	3.83	45	5.11	20	11.25	12	19.17	12	19.17
9	Clearview to 9@Snohomish	7.49	50	8.99	30	15.09	19	23.57	19	23.57
9	9@Snohomish to 2xing	1.2	55	1.31	44	1.63	28	2.59	28	2.59

Source: HDR Engineering, links aggregated from TDM CD data provided by the WSDOT Transportation Planning Office

Table 5
Travel Delay Methodology (TDM) Derived Network Link Travel Times and Speeds for TDM Horizon Years (continued)

Route	Link Description	Length (miles)	Posted Speed (mph)	Free Flow Travel Time (minutes)	1998 Congested Travel Speed (mph)	1998 Congested Travel Time (minutes)	2022 “No-Build” Congested Travel Speed (mph)	2022 “No-Build” Congested Travel Time (minutes)	2022 “Build” Congested Travel Speed (mph)	2022 “Build” Congested Travel Time (minutes)
9	2xing to lake Stevens	4.79	50	5.75	33	8.71	23	12.46	23	12.46
9	Lake Stevens to 530xing	12.33	46	16.08	39	19.20	27	27.78	27	27.78
9	530xing to Pilchuck	4.85	55	5.29	60	4.83	59	4.96	59	4.96
9	Pilchuck to Montbourne	9.74	55	10.63	61	9.63	60	9.75	60	9.75
9	Montbourne to 538xing	4	50	4.80	54	4.42	51	4.70	58	4.16
9	538xing to 20xing	6.09	44	8.30	48	7.67	43	8.58	48	7.59
20	Oak Harbor to 20xing	15.27	48	19.09	33	27.80	25	36.75	25	36.75
20	Anacortes to 20xing	3.86	30	7.72	45	5.16	27	8.67	36	6.43
20	20xing to Fredonia	6.92	55	7.55	53	7.83	42	9.81	49	8.43
20	Fredonia to 5xing	4.62	55	5.04	38	7.33	23	11.80	23	11.84
20	5xing to Burlington	0.9	32	1.69	31	1.74	23	2.33	23	2.33
20	Burlington to 9xing	4.48	46	5.84	36	7.42	20	13.14	29	9.31
20	9xing to Sedro Woolley	1.26	35	2.16	20	3.82	8	9.32	31	2.40
405	Bellevue to 520xing	2.07	60	2.07	30	4.19	16	7.79	16	7.79
405	520xing to 522xing	8.9	60	8.90	41	13.04	19	27.86	19	27.86
405	522xing to 5/525xing	6.54	60	6.54	22	17.47	14	27.76	14	27.76
525	5xing to Mukilteo	6.96	47	8.89	16	25.61	9	45.17	9	45.17
526	5xing to Mukilteo	4.52	49	5.53	46	5.87	35	7.80	35	7.80
530	5xing to 9xing	3.84	53	4.35	39	5.95	28	8.35	28	8.35
530	9xing to Trafton	4.47	48	5.59	43	6.22	26	10.12	26	10.12
532	Camano to Stanwood	5.25	42	7.50	29	10.84	21	14.81	21	14.81
532	Stanwood to 5xing	4.84	45	6.45	24	12.13	17	17.33	17	17.33
538	5xing to 9xing	3.66	34	6.46	34	6.49	26	8.30	26	8.30
539	5xing to Lynden	10.8	48	13.50	21	30.99	16	41.35	29	22.06
539	Lynden to 1-13CAN	4.36	47	5.57	42	6.27	33	7.92	50	5.26
542	5xing to East Bellingham	2.1	35	3.60	26	4.80	18	6.95	28	4.46

Source: HDR Engineering, links aggregated from Travel Delay Methodology CD data provided by the WSDOT Transportation Planning Office.